DOCUMENT RESUME

ED 215 325 CS 006 624

AUTHOR Duchastel, Philippe C.
TITLE Selective Learning: An Interpretive Review of Orienting Factors in Prose Learning.
PUB DATE 78
NOTE 27p.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Behavioral Objectives; *Learning Processes; *Learning Theories; *Prose; Questioning Techniques; Reading Processes; Reading Research; Research Methodology
IDENTIFIERS Adjunct Aids; *Mathemagenics; *Prose Learning

ABSTRACT

Defining mathemagenics as adjunct aids that can be used in textual situations to enhance learning, this paper places a new perspective on mathemagenics research as well as on practical considerations derived from that research. Specifically, the paper addresses two questions: (1) Which explanatory concepts--degree of processing, selective learning, or rehearsal and integration--are best at describing the processes that are operative in mathemagenic situations? and (2) What practical advice can be given about the appropriate use of adjunct aids in prose learning situations? Through a review of the literature the paper concludes that selective learning can play a major explanatory role, not only theoretically but also in the practice of improving prose learning through mathemagenics. (FL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED215325

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.
Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

SELECTIVE LEARNING:

AN INTERPRETIVE REVIEW OF ORIENTING FACTORS

IN PROSE LEARNING

Philippe C. Duchastel
The American College
Bryn Mawr, Pennsylvania

Note: This paper was written in the early part of 1978 when I first became interested in examining the conclusions to be drawn from the mathemagenic literature. It is very much a "thinking paper" and as such is rather lacking in precision of expression and organization. It nevertheless contains viewpoints which may be of interest to others exploring this field of research. A number of the issues presented here have been considered further in a subsequent paper entitled Adjunct Questions Effects and Experimental Constraints, which is listed in the reference section.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Philippe C. Duchastel

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CS006624

Since this paper considers the practical use of learning objectives and adjunct questions, a number of these have been inserted in the paper to illustrate some of the points being made. The reader should consider these adjunct aids as he reads the paper.

Prose learning is receiving an increasing degree of attention in the instructional research literature and that trend is likely to be a continuing one. There are essentially two reasons for this: the current interest in cognitive explanations of psychological phenomena carries with it the need for a more refined approach to experimentation, as can be obtained with prose manipulations; and, more specifically, prose itself is becoming more and more amenable to precise specification by attempts to describe its content structure. Both of these points will be taken up later in this paper, after I first delineate the problem we will be dealing with and introduce a few qualifications on the scope and the nature of the review proposed.

Prose is a medium which carries an intended message of instruction and as such, it can be more or less effectual. The medium itself can either make or break learning, so to speak, although in practice what we are concerned with is the degree to which learning can be facilitated by this medium. We are reminded here of the very valuable distinction between nominal stimuli and effective stimuli which was introduced in educational psychology by Rothkopf (1970). This distinction, I believe, has been of immense help to instructional researchers in thinking about what goes on when a learner is reading a prose passage. It brings out the variable status of <u>what</u> is being read at any one moment. Put bluntly, even if at a certain risk, it says quite simply that the more you pay

attention to what you are reading, the better you will learn it. In other words, the message within prose must be processed if it is to be retained and the degree of such processing will affect learning. Or is it the kind of processing rather than the degree of processing which affects learning? That shall be the main issue which will be explored in this review paper.

What I will be concerned with is an examination of the mathemagenic research literature with a view to clarifying the above question. What is offered here is not another review of the mathemagenic literature in any comprehensive manner, but rather an analytical consideration of this literature from a particular viewpoint. A number of reviews are already available in this area (including Rothkopf, 1970, 1976; Frase, 1970, 1975A; Duchastel & Merrill, 1973; Ladas, 1973; Bull, 1973; Barry, 1974; Anderson & Biddle, 1975; Hartley & Davis, 1976; Faw & Waller, 1976; Nelsson, 1977; Dayton, 1977; Wittrock, 1977; Rickards, 1977, 1978; Rickards & Denner, 1978; Melton, 1978). These reviews cover a wide range of interpretive approaches, some more theoretical, others very practical in nature (conclusion-oriented versus decision-oriented formulations of educational research - Cronbach and Suppes, 1969) and this in itself raises the interesting issue concerning the legitimate generalization of basic experimental findings to practical educational settings. Something shall be said further on about this problem, for it is much more of a problem, I believe, than is often thought to be the case.

Who wrote the first ever review paper on mathemagenics? In what year?

The questions then which will be addressed in this paper are the following:

1/ Which explanatory concepts are best at describing the processes which are operative in mathemagenic situations: degree of processing, selective learning, rehearsal and integration, . . .?

2/ What practical advice can be given about the appropriate use of adjunct aids in prose learning situations?

As the title of this review indicates, selective learning plays a major role, although not an exhaustive one, in answering these two questions.

Two qualifications need to be made before embarking on these issues. The first concerns the scope of mathemagenics as used here. As intended by Rothkopf, the term mathemagenics covers all adjunct aids (and more still! - cf. Rothkopf, 1970). Past reviews have at times only been concerned with inserted questions, or with instructional objectives; at other times, they have also considered advance organizers (certainly an adjunct aid!), typographical cueing, note-taking, etc. The usage of the term is a rather free one, given the breadth of its initial conception, and this may not be a bad state of affairs for the advancement of research. However, from a theoretical point of view it can be misleading. In this review, I shall deal only with inserted questions and learning objectives and not with other adjunct aids. The reason for focus is mainly a practical one.

The second point which needs to be mentioned is that this review differs from many not only by not attempting to be comprehensive, but also by its freer use of conjecture in exploring theoretical viewpoints. What is referred to here is the adoption of a speculative style in examining the literature, a style which may initially annoy some readers, but which on the whole, and especially if taken in the spirit of hypothesis formulation, could prove to be extremely useful in interpreting the claims of mathemagenics.

The field is still a relatively confused one, with researchers being somewhat too cautious at times in interpreting their observed effects, while at other times being too expansive in generalizing them to applied contexts. A good deal of this confusion is due I believe to the particular experimental context which frames much of mathemagenic research, as we shall see later, and the present review is an attempt, following on those of others, to come out from the mass of detailed findings with some kind of general framework which takes this particular context into account.

PROCESSING IN MATHEMAGENIC RESEARCH

A Cognitive Orientation

You should consider especially what is emphasized by each of the two research orientations discussed in this section.

Mathemagenic research is best considered as a psychological rather than an educational line of research. This may sound surprising at first, for two reasons: (i) the research is often couched in educational terms and is to a large extent reported in educationally oriented journals such as the RER and the Journal of Educational Psychology; and (ii) education and psychology in any case overlap to such an extent that attempting to separate them may appear quite artificial. Despite these drawbacks, there is a stronger advantage, I feel, in distinquishing between these two lines of research in examining the mathemagenic research (cf. also Cronbach and Suppes, 1969; and Frase, 1973). Essentially, an educational orientation seeks to inform practice and emphasizes external validity or generalizability of findings. This, as we shall see later on, the mathemagenic research

does not generally do. On the other hand, a psychological orientation is aimed at making sense of given learning situations and, to do this, it must emphasize especially internal validity or experimental control. The questions of interest in this line of research are explanatory ones: what is of concern is not so much that inserted questions enhance learning but, more importantly, why and how they do so; in other words, what processes are occurring when a learner encounters inserted questions while reading a prose passage.

Mathemagenic research has for the most part attempted to embrace both orientations at least tacitly. Its most interesting aspect, however, is certainly its psychological orientation. Its concern for a finer analysis of the learning of prose (for instance the early distinction between nominal and effective stimuli referred to above) has made it somewhat of a leader within educational psychology as a whole in this respect. The current cognitive orientation in psychology is now bringing these concerns even more to the fore (cf. Frase, 1975a and Anderson & Biddle, 1975) and this makes it more and more relevant to consider the area in a psychological rather than an educational framework. The recent extensive review by Rickards and Denner (1978), for instance, includes a historical development of mathemagenic research and points out the recent swing towards an essentially process-centered cognitive orientation.

Basic Findings

Inasmuch as it is possible to generalize from the literature as a whole (cf. the reviews listed in the introduction), it is interesting as a first step to ask what the effects of inserted questions and objectives are on learning. Put very summarily, these are as follows:

(i) inserted post-questions tend to increase relevant learning (the term refers to learning directly related to the inserted questions) and additionally, to increase incidental learning as well (learning not directly related to the inserted questions);

(ii) inserted pre-questions tend to increase relevant learning and depress incidental learning;

(iii) learning objectives have the same effects as pre-questions.

The description of these effects in terms of relevant and incidental learning is intentional, despite the fact that it may already show an interpretational bias toward the concept of selective learning.

Quite naturally, the research evidence from which the above conclusions are derived is not wholly consistent, nor is it fully supportive of them. For instance, a number of studies have failed to show any facilitative role for objectives and a few of them have even found objectives to increase incidental learning (cf. Melton, 1978). Likewise, pre-questions have not always depressed incidental learning. This is not altogether surprising considering that mathemagenic factors probably vary according to context (motivation, students, type of passage, etc.) and, as we shall see later on, they are most likely determined in part by the experimental constraints imposed on the learning task. Thus, despite the fact that the evidence is not clear-cut, I believe that most researchers would agree with the three summary conclusions stated above, inasmuch as they represent general statements concerning mathemagenics.

The conflicting evidence, however, does suggest an important consideration, namely that mathemagenic factors are strongly context/task specific. This is the crux of the matter and leads directly to an examination of the processes underlying learning in mathemagenic situations.

Degree of Processing

With which recent view of memory does the degree of processing interpretation tie in with?

The fact that mathemagenic factors generally increase the overall level of learning could be simply interpreted in terms of increased processing. Indeed, this essentially constituted the early explanation put forward for the effects observed (Rothkopf, 1970). Inserted questions, in this view, engendered mathemagenic activities in the learner, i.e., engendered increased processing whereby more of the stimuli in a passage which were initially merely nominal stimuli were transformed into effective stimuli. This is a rough view of the phenomenon and still holds much in terms of explanatory power at a general level of representation of the phenomenon. It also ties in coherently with related views of learning. For one, the well-established maxim proclaiming the value of active learning can be seen as a precursor here. For another, it fits in closely with a recent view of memory phenomena proposed by Craik and Lockhart (1972), a view directly based on depth of processing. And for yet another, it fits nicely into a view of reading behaviors as involving varying degrees of active processing of the text: from a quick skim at one extreme, to Neisser's (1967) description of reading as "externally guided thinking" at the other.

Degree of processing, however, seems too parsimonious a concept to offer anything but a rough sketch, although a generally acceptable one, of what is actually occurring in mathemagenic situations. Inserted questions (both pre-and post-questions) and objectives do increase processing of a

text, but they do so in particular ways. In other words, they engender different kinds of increased processing.

With which three views of learning did the degree of processing interpretation be said to tie in with?

Types of Processing

That various mathemagenic factors differentially affect the type of processing which the learner engages in is demonstrated most clearly by the fact that learning outcomes will vary according to the mathemagenic situations which frame the learning context. Both subjects with and without learning objectives for instance may learn the same amount of material from a text, and yet learn different things from the text. This is shown in a number of studies, an example of which is a study by Duchastel and Brown (1974). That the two groups of subjects learned different things from the text clearly implies that they were attending differently to the text, i.e., that they processed the text in at least slightly different ways.

The question of interest then is how these different processing strategies engendered by mathemagenics can be described in such a way as to offer a meaningful explanation of the observed phenomena? The two most promising explanations which have been suggested (cf. Frase, 1975a; Anderson & Biddle, 1975; Rothkopf, 1976) are selective attention, and mental review. This is not to say that other processing activities may not also be operative in mathemagenic situations (processes such as repetition, organization, or arousal for instance) but rather that these latter processes are probably of lesser importance in explaining the mathemagenic effects than are selection

and review. Rickards' stimulating analysis of processes in post-question research can also be understood in terms of these two processes (Rickards, 1969).

It becomes necessary at this point to deal separately with pre-questions and objectives on the one hand and post-questions on the other, for the processes they are believed to engender are rather different from each other. The general findings from the research on pre-questions and objectives seem best explained in terms of a selective attention hypothesis. In other words, what pre-questions and objectives do is to orient the learner to certain parts or aspects of the text just as straightforward directions would do in simpler situations. Tell your students to concentrate on Chapter 4 of the textbook for the examination and you can be pretty sure that most of them will learn that chapter better than the other chapters! Selective learning is no more than intelligent behavior on the part of the student, who has to decide from moment to moment just what is especially important to learn and what is less so. Learning objectives help him do just that and it is likely that pre-questions do so as well. They both constitute attentional devices which more or less overtly flag the importance of the material as it is read. In Rothkopf's terms, they change the status of given items from being nominal to effective stimuli. This is effected by greater processing of the items flagged as important and by a lesser degree of processing for the non-flagged items. However, the degree to which the process of selectivity in learning actually affects what is learned, for it is not an all-or-none matter, is an important consideration and shall be elaborated upon further later on.

It is appropriate first to turn to the general findings from the research on post-questions and consider the mental review explanation. Mental

review or rehearsal is in a sense no more than a greater processing of the text elements, albeit a delayed processing acting on recent memory of the text stimuli rather than on the printed stimuli themselves (cf. Anderson and Biddle, 1975, who develop this theme very cogently). Indeed, most of the research on post-questions involves learning situations in which the learners are prevented from backtracking to the relevant parts of the text. This is understandable on methodological grounds, for otherwise post-questions could additionally become pre-backtrack questions as well. The evidence from the post-question research, in terms of enhanced relevant learning, suggests that mental review processes are indeed operative in this mathemagenic situation. Whether this retrospective processing is best described in terms of simple retrieval and rehearsal, or within a cybernetic model of self-assessment, or in terms of cognitive integration is yet a deeper issue, which will require further theoretical elaboration and empirical testing in the future (cf. Anderson and Biddle, 1975 for a start in this line of research). The important point for now is to simply be able to describe the phenomenon in terms of a mental review process. This could go somewhat as follows: upon encountering a question, a student interrupts his reading of the text to try to answer the question posed; this is presumed to involve an active response (although a covert one) on the part of the student and constitutes as such further processing of the element constituting the response, i.e., mental review.

That, however, is but one side of the post-question research. Mathemagenic researchers have been primarily concerned with the effects of post-questions on incidental learning. Why should post-questions enhance incidental learning? An indirect mental review hypothesis is possible, whereby

incidental material is reviewed somewhat in the background during the mental search for the relevant material. This indirect review hypothesis has been supported by a few studies although the effect is very small (cf. Rickards' review of what he has called the general backward effect, 1978). It remains somewhat surprising nevertheless, considering the type of material usually employed, i.e., factual information with relatively low interconnectedness. To what extent this indirect review process is an important one or not is, therefore, a matter of some concern. However, its role should grow with more connected discourse, as suggested in a study by Rickards & DiVesta (1974).

A more applicable hypothesis may be quite simply the degree of processing one. The expectation of an inserted post-question on a section of the text, coupled with uncertainty as to precisely which element in that section will be tested, may well induce in the subject a generalized and more active processing of all the elements in the section as it is being read. This is in essence the classic interpretation intially advanced by Rothkopf (1970). One implication of this view would be that the number of questions encountered in the text, as long as uncertainty is maintained, should correlate with the amount of incidental learning. Another aspect of this interpretation is that any induced extra processing would necessarily be additional to that already induced by the expectation of a terminal post-test. As far as I know, both of these implications remain to be examined.

Generalized more thorough processing, however, should result only when uncertainty as to the nature of the coming post-questions is maintained. If this uncertainty is dispelled, for instance by the recurrence of a given type of question, then incidental learning will decline. This is precisely

what Rothkopf & Bisbicos (1967) found when the post-questions they presented to their subjects all required given types of information as answers (such as technical terms) rather than more common and hence more varied answers. This same type of finding has been replicated by other researchers (cf. the reviews by Anderson & Biddle, 1975 and by Rickards, 1978; also Howe & Colley, 1976).

What are the extended implications of the Rothkopf and Bisbicos study?

Conclusions

Consideration of these studies in this light does suggest, therefore, that mathemagenic factors in prose processing are indeed strongly context-framed, as implied earlier. What effects mathemagenic aids will have on learning will depend to a great extent on how the situation cues the learner as to which processing strategy to adopt. This surely is far from unexpected, yet relatively little attention seems to be given to it in interpretations of the research literature.

What then may we conclude with respect to the issue about degree versus kind of processing? The research as a whole would seem to favor a compound interpretation, one which includes both views and yet which qualifies the extent to which each may play a central role in a given context.

With post-questions, generalized increased processing does seem to occur when uncertainty as to type of item is maintained. This greater degree of processing applies to both incidental and relevant learning and explains the superiority of post-question situations over text-alone situations. As for the enhanced learning of relevant over incidental material, this would simply seem to be a factor of selective practice, or selective mental review.

With pre-questions on the other hand, as well as with learning objectives, degree of processing would seem to lose out to selective processing of the relevant material. This is not to say that what is selected is not processed more thoroughly than it would be otherwise - for this is indeed the case, as evidenced by improved relevant learning. Rather what is meant here is that the text as a whole is not processed at a greater depth - some of it is and some of it is processed at a lesser depth. A selective learning process is taking place. This also results when post-questions are employed in a context which impairs uncertainty, as happens when the regularity of a type of question becomes apparent to the learner, or when the learner is allowed to backtrack and review the material, as we shall see in the following section.

Thus, as used in the traditional experimental paradigm, post-questions would seem to support a dual explanation consisting of increased processing and selective learning, while pre-questions and objectives favor mainly a selective learning explanation. It will be argued in the next section, however, that the increased processing component in the explanation of post-question effects might simply be due in some part (of unknown importance) to the constraints of the traditional paradigm.

In which mathemagenic situations does selective learning play an important role?

Before that, however, it would be appropriate to conclude this section on theoretical explanations by briefly tying in the current discussion to Rickards' (1978) analysis of processes and by a final comment on depth of processing.

Rickards has outlined two types of processing engendered by the use of post-questions, a forward one (related to text sections to come) and a backward one (related to text sections just read). In addition, each of these processes can be specific in scope (what I have been calling relevant learning) or general in scope (incidental learning). The concept of selective learning as developed in the present discussion would properly cover both forms of Rickards' specific processes while increased processing would relate to his general processes. The two systems of explanation are simply two ways of summarizing the mathemagenic literature, with perhaps a greater emphasis on the relative importance of each type of process in the current discussion.

In what year was the Craik & Lockhart paper published?

As for the concept of the degree of processing, the term is still relatively unclear and subject to confusion with depth of processing (Craik & Lockhart, 1972). What does it mean to more thoroughly process a section of text? Does it mean that the text is processed longer, or more actively, or more meaningfully (whatever these abstract terms may themselves mean). The term 'depth of processing' has come to represent in verbal learning research an increase in semantic processing, as opposed to less involved forms of processing such as phonological processing (Craik & Tulving, 1975). Semantic processing itself, however, overlaps somewhat with the terms listed above as potential qualifiers of 'degree of processing'. Thus, depth of processing would also seem to present a certain fuzziness in its character. I prefer to think of degree of processing, therefore, as simply reflecting more thorough processing, this being of a semantic nature if we are dealing with elaborated ideas or simply of a rehearsal nature if we are dealing with facts. This, however, constitutes an altogether different level of analysis and it

is not the appropriate place here to further disambiguate these terms (cf. Anderson, 1970, for a good start in this direction). I want merely to point to an area which is bound to prove of some concern in the future, and to indicate a reliance for the time being on our intuitive understanding of the term 'degree of processing'.

When were the following two papers published: Craik & Lockhart and Craik & Tulving?

It is not difficult to see that degree of processing and type of processing are in reality closely intertwined. Type of processing, as used here, refers to what is being processed and when, as well as to how it is processed (from memory, as in mental review, or during reading, as in selective learning). Once type of processing is engaged, degree of processing then follows. Thus, it is only in order to interpret these processes and to offer a framework for understanding them that the issue can be put in terms of degree versus type of processing.

IMPROVING PROSE LEARNING

It was stated at the beginning of the previous section that mathemagenic research is best considered as a psychological line of research, at least in interpreting the literature. Interest in the area is less concerned with the issue as to what can occur as it is with the question as to why it occurs.

Yet despite this favored view of the area, the utilization of adjunct aids of all kinds to engender mathemagenic activities in practical prose learning situations remains of high concern to educators. Research, however, can often only guide practice in an indirect way, albeit in a powerful one, by shaping given patterns of thought with respect to active decision-making

(Kuhn, 1962; Cronback & Suppes, 1969). This is what seems to be happening with the mathemagenic research as a whole. It is influencing practice, especially in the areas concerned with the use of instructional objectives and post-questions, and this despite the general non-educational orientation of the research. It is therefore an issue worth pursuing.

Mathemagenics in Natural Settings

Most of the studies on instructional objectives were conducted in fairly naturalistic settings. By this is meant especially that the learning materials used and the task constraints involved in the studies approximated to a fair degree some real school learning situations. This, of course, is not true of all studies, but on the whole, one finds the bulk of the studies of direct generalizable value.

A different and more complex picture, however, arises in the area of inserted questions. Here, numerous studies have intentionally utilized artificialized situations in order to control the use made of and hence the very nature of the questions. More specifically, post-questions have usually been included in an experimental paradigm which insisted on the learner processing the text sequentially, that is without the opportunity for review (at least, not after having encountered the inserted questions). As mentioned earlier, this was a necessary investigatory tactic to preserve the very function of the post-questions - otherwise these may very well have been used as pre-questions or, in the least, they may have played a much more mitigated role. This functional assumption, however, has often been underplayed in the literature, with the result that generalizability of these research findings to more naturalistic settings is often too readily assumed.

It is instructive to examine the few studies which most closely parallel a contraint-free setting in this respect (Washburne, 1929; Gustafson & Toole, 1970; Hiller, 1974). These researchers allowed their subjects to adopt a free reading strategy by enabling review of the material after encountering inserted post-questions. In all three studies, post-questions generally failed to enhance incidental learning, as they usually do with the traditional but less naturalistic paradigm, and in some conditions of the Washburne and Hiller studies, incidental learning was even depressed. Post-questions seem here then to have shaped a selective learning strategy rather than (or perhaps in addition to) a generalized greater processing one. It is in this sense that the mental review explanation for post-questions may be something of a procedural artifact and hence play but a small part in the total picture. This issue is examined in some detail in Duchastel (1979a).

Was it Hiller or Gustafson & Toole who published before the other?

Mathemagenics and Knowledge Structures

A further issue of concern for the pragmatics of mathemagenics is the problem of levels of knowledge.

A surprising proportion of the studies on mathemagenics have dealt with the learning of factual knowledge as opposed to higher order levels of knowledge. This proclivity for utilizing factual learning material in experimental studies is understandable, given the desirability to reduce unaccountable variance in research. However, it does make the jump from research to application an even more difficult one than may often be thought the case.

Some studies, reviewed in detail by Rickards (1977), have directly investigated differential effects of levels of learning by employing a categorization such as Bloom's (1956). The overall picture emerging from these studies, however, is a complex and ambiguous one, with seemingly little total consenses.

Another, more recent, approach to knowledge is the cognitive structure approach (Hayes-Roth, 1977; Norman, 1976) which de-emphasizes the cumulative aspect of learning and focuses on structural characteristics of the internal representation of knowledge.

This shift, I believe, will eventually prove to be a profound one for learning psychology, for it is bound to have an impact not only on what is measured as learning but also on the methodology with which we approach the problems of meaningful and coherent learning. Bartlett's Remembering (1932) may be revisited in more than one way in this respect.

This shift in our view of learning is likely to have some impact on our consideration of mathemagenics, both theoretically and in practice. We are still a long way off from that day, however, and in the meantime, I expect we shall quite properly see a surge of interest in the structure of text, although within the familiar cumulative learning paradigm rather than the cognitive structure one. The explicit description of the structure of a text is an important aim in our search for understanding in prose learning and a number of pionners have cleared the ground in this area (Crothers, 1972; Fredericksen, 1972; Meyer, 1975; also Frase, 1975b). This has enabled a more precise characterization of the textual materials employed in mathemagenic studies (e.g., Duchastel, 1979b).

Knowledge structures are difficult to analyze and school learning is more complex than we researchers generally like to imagine it to be (cf. Anderson, et. al, 1977, for an initial analysis of this issue). Learning

can be described differently depending on the level of analysis adopted in a given investigation: the level of macro-cognitive structures or that of micro-elements of knowledge are two rather different levels of description, each as valid as the other, of course, within its particular framework. Ausubel (1963) has long recognized this view, and current trends in instructional research (cf. Anderson et. al, 1977) are seen as developing a theoretical outlook not unrelated to this framework.

Mathemagenic research has up till now provided us with some indications for action within the elemental level of analysis when it comes to practical school learning. What remains in store for us within a different level of analysis of knowledge structures will most likely be an exciting venture. The outcome of such a process of broadening our concerns within the area of learning will certainly add a new dimension to the role which mathemagenics can play in real instructional settings.

Conclusions

If, as has been argued in this paper, selective learning can play a major explanatory role, not only theoretically but also in the practice of improving prose learning through mathemagenics, where do we stand in the realm of action? How do we use mathemagenics to improve learning? Strong value judgments necessarily enter the picture at this point. If one believes, as I do, that most academic learning materials can be considered to contain some incidental material of rather secondary importance, especially at the higher educational level, then selective learning should be encouraged. For, in naturalistic settings, it is at the expense of incidental learning that relevant (and, by definition, important) learning will be enhanced. The mathematics of the trade-off are not so simple, however, for in addition to encouraging selective learning, mathemagenic factors most likely also

have some effect along the lines of generally increasing the level of processing of the text as a whole. The effects are not after all mutually exclusive, except in extreme cases. What has been argued here is not that selective learning is the only process generated by mathemagenics in natural settings, but rather that is is the most important of the processes.

Mathemagenic factors are also known to interact with the learner's own selection strategies, as is evidenced by Duell's valuable study on this issue (1974). Students to some extent engage in selective learning quite on their own; what mathemagenics can do, as objectives did in Duell's study, is to point out additional aspects of the text for selective and more thorough processing, beyond those already opted for by the student. What mathemagenics do then is to sharpen the student's perception of the task by providing him or her with the text author's own perception of importance of the text elements.

SUMMING UP

The intent of this paper was to place a new perspective on mathemagenic research as well as on practical considerations derived from the research. The interpretation resulting from this analysis is one which emphasizes selective learning both as a main explanatory factor in the research literature (along with mental review) and as a basis for the pragmatic side of mathemagenics in real school settings. There is also the strong possibility that the mental review factor is mainly a context-bound phenomenon, although one would intuitively believe it to exist to some degree in naturalistic settings as well.

The paradigmatic peculiarity of much of mathemagenic research on post-questions is essentially the reason why I feel it advantageous to view

mathemagenic research primarily as a psychological concern and only secondarily as an educational one (despite the certain importance of the latter, to be sure).

Mathemagenics, especially under the impetus and continued support provided by Rothkopf and his colleagues at Bell Laboratories, have done much over the years to increase the educator's interest in the use of questions and the instructional researcher's concern for text processing. These are developments of great importance to instruction. Building on that, I feel the time is now ripe for a true extension of mathemagenics to concerns involving pragmatics.

REFERENCES

Anderson, R. Control of Student Mediating Processes During Verbal Learning and Instruction. Review of Educational Research, 1970, 40, 349-370.

Anderson, R. and Biddle, W. On Asking People Questions about What They are Reading. In G. Bower (ed.) The Psychology of Learning and Motivation, 9. New York: Academic Press, 1975.

Anderson, R., Spiro, R. and Montague, W. Schooling and the Acquisition of Knowledge. Hillsdale, N.J.: Erlbaum Associates, 1977.

Ausubel, D. The Psychology of Meaningful Verbal Learning. New York: Grune and Stratton, 1963.

Barry, R. The Concept of Mathemagenic Behaviour: An Analysis of its Heuristic Value. Perceptual and Motor Skills, 1974, 38, 311-321.

Bartlett, F. Remembering. Cambridge University Press, 1932.

Bloom, B. (ed.) Taxonomy of Educational Objectives: Cognitive Domain. New York: David McKay, 1956.

Bull, S. The Role of Questions in Maintaining Attention for Textual Material. Review of Educational Research, 1973, 43, 83-88.

Craik, F. and Lockhart, R. Levels of Processing: A Framework for Memory Research. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 671-684.

Craik, F. and Tulving, E. Depth of Processing and the Retention of Words in Episodic Memory. Journal of Experimental Psychology: General, 1974, 104, 268-294.

Cronbach, L. and Suppes, P. (eds.) Research for Tomorrow's Schools: Disciplined Inquiry for Education. London: Macmillan, 1969.

Crothers, E. Memory structure and recall of discourse. In J. Carroll and R. Freedle (eds.) Language Comprehension and the Acquisition of Knowledge. Washington, D.C.: Winston, 1972.

Dayton, D. Inserted Post-Questions and Learning from Slide-Page Presentations: Implications for the Mathemagenic Hypothesis. AV Communication Review, 1977, 25, 125-146.

Duchastel, P. Adjunct Questions Effects and Experimental Constraints. Occasional Paper 1, Department of Research and Evaluation, The American College, Bryn Mawr, Pennsylvania, 1979a.

Duchastel, P. Learning Objectives and the Organization of Prose. Journal of Educational Psychology, 1979b, 71, 100-106.

Duchastel, P. and Brown, B. Incidental and Relevant Learning with Instructional Objectives. Journal of Educational Psychology, 1974, 66, 481-485.

Duchastel, P. and Merrill, P. The effects of Behavioral Objectives on Learning. Review of Educational Research, 1973, 75, 250-266.

Ehrlich, S. Apprentissage et Memoire chez l'Homme. Presses Universitaires de France, 1975.

Faw, H. and Waller, G. Mathemagenic Behaviours and Efficiency in Learning from Prose. Review of Educational Research, 1976, 46, 691-720.

Frase, L. Boundary Conditions for Mathemagenic Behaviors. Review of Educational Research, 1970, 40, 337-348.

Frase, L. On Learning from Prose. Educational Psychologist, 1973, 10, 15-23.

Frase, L. Prose Processing. In G. Bower (ed.) The Psychology of Learning and Motivation, 9, New York: Academic Press, 1975.

Fredericksen, C. Effects of task-induced cognitive operations on comprehension and memory processes. In J. Carroll and R. Freedle (eds.) Language Comprehension and the Acquisition of Knowledge. Washington, D. C.: Winston, 1972.

Gustafson, H. and Toole, D. Effects of Adjunct Questions, Pretesting and Degree of Student Supervision on Learning from an Instructional Text. Journal of Experimental Education, 1970, 39, 53-58.

Hartley, J. and Davies, I. Preinstructional strategies: The Role of Pretests, Behavioral Objectives, Overviews and Advance Organizers. Review of Educational Research, 1976, 46, 239-266.

Hayes-Roth, B. Evolution of Cognitive Structures and Processes. Psychological Review, 1977, 84, 260-278.

Hiller, J. Learning from Prose Text: Effects of Readability Level, Inserted Question Difficulty, and Individual Differences. Journal of Educational Psychology, 1974, 66, 202-211.

Howe, M. and Colley, L. The Influence of Questions Encountered Earlier on Learning from Prose. British Journal of Educational Psychology, 1976, 46, 149-154.

Kuhn, T. The structure of Scientific Revolutions. University of Chicago Press, 1962.

Ladas, H. The Mathemagenic Effects of Factual Review Questions on the Learning of Incidental Information: A Critical Review. Review of Educational Research, 1973, 43, 71-82.

Melton, R. Resolution of Conflicting Claims Concerning the Effect of Behavioural Objectives on Student Learning. Review of Educational Research, 1978, 48, 291-302.

Neyer, B. The Organization of Prose and its Effects on Memory. New York: American Elsevier, 1975.

Neisser, U. Cognitive Psychology. New York: Appleton-Century Crofts, 1967.

Nelsson, O. Mathemagenic Activities and Teaching. A Review. Pedagogical Reports, No. 7, Department of Education, University of Lund, Sweden, 1976.

Norman, D. Memory and attention. New York: Wiley, 2nd ed. 1976.

Rickards, J. On Inserting Questions Before or After Segments of Text. Contemporary Educational Psychology, 1977, 2, 200-206.

Rickards, J. Adjunct Postquestions in Test: A Critical Review of Methods and Processes. Review of Educational Research, 1979, 49, 181-196.

Rickards, J. and DiVesta, F. Type and Frequency of Questions in Processing Textual Material. Journal of Educational Psychology, 1974, 66, 354-362.

Rickards, J. and Denner, P. Inserted Questions as Aids to Reading Text. Instructional Science, 1979.

Rothkopf, E. The Concept of Mathemagenic Activities. Review of Educational Research, 1970, 40, 325-336.

Rothkopf, E. Writing to Teach and Reading to Learn: A perspective of the Psychology of Written Instruction. Seventy-fifth Yearbook of the National Society for the Study of Education, Part 1, 1976, 91-129.

Rothkopf, E. and Bisbicos, E. Selective Facilitative Effects of Interspersed Questions on Learning from Written Materials. Journal of Educational Psychology, 1967, 58, 56-61.

Washburne, J. The use of Questions in Social Science Material. Journal of Educational Psychology, 1929, 20, 321-359.

Wittrock, M. and Lumsdaine, A. Instructional Psychology. Annual Review of Psychology, 1977, 28, 417-460.